

## LM2660 Switched Capacitor Voltage Converter

Check for Samples: [LM2660](#)

### FEATURES

- Inverts or Doubles Input Supply Voltage
- Narrow SO-8 and Mini SO-8 Package
- $6.5\Omega$  Typical Output Resistance
- 88% Typical Conversion Efficiency at 100 mA
- Selectable Oscillator Frequency: 10 kHz/80 kHz
- Optional External Oscillator Input

### APPLICATIONS

- Laptop Computers
- Cellular Phones
- Medical Instruments
- Operational Amplifier Power Supplies
- Interface Power Supplies
- Handheld Instruments

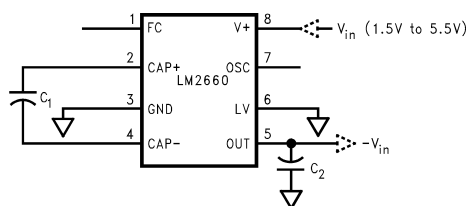
### DESCRIPTION

The LM2660 CMOS charge-pump voltage converter is a versatile unregulated switched capacitor inverter or doubler. Operating from a wide 1.5V to 5.5V supply voltage, the LM2660 uses two low-cost capacitors to provide 100 mA of output current without the cost, size and EMI related to inductor-based converters. With an operating current of only 120  $\mu$ A and operating efficiency greater than 90% at most loads, the LM2660 provides ideal performance for battery-powered systems. LM2660 devices can be operated directly in parallel to lower output impedance, thus providing more current at a given voltage.

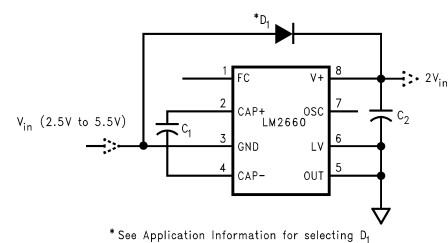
The FC (frequency control) pin selects between a nominal 10 kHz or 80 kHz oscillator frequency. The oscillator frequency can be lowered by adding an external capacitor to the OSC pin. Also, the OSC pin may be used to drive the LM2660 with an external clock up to 150 kHz. Through these methods, output ripple frequency and harmonics may be controlled.

Additionally, the LM2660 may be configured to divide a positive input voltage precisely in half. In this mode, input voltages as high as 11V may be used.

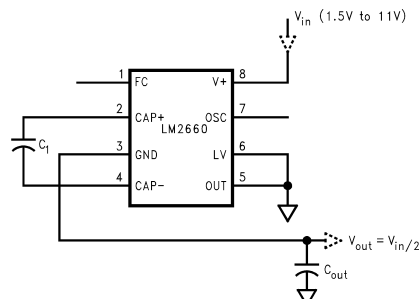
### Basic Application Circuits



**Figure 1. Voltage Inverter**



**Figure 2. Positive Voltage Doubler**



**Figure 3. Splitting  $V_{IN}$  in Half**



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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### Absolute Maximum Ratings <sup>(1)(2)</sup>

Supply Voltage (V+ to GND, or GND to OUT)		6V	
LV		(OUT – 0.3V) to (GND + 3V)	
FC, OSC		The least negative of (OUT – 0.3V) or (V+ – 6V) to (V+ + 0.3V)	
V+ and OUT Continuous Output Current		120 mA	
Output Short-Circuit Duration to GND <sup>(3)</sup>		1 sec.	
		<b>Package</b>	
		<b>SOIC (D)</b>	<b>VSSOP (DGK)</b>
Power Dissipation	(T <sub>A</sub> = 25°C) <sup>(4)</sup>	735 mW	500 mW
	T <sub>J</sub> Max <sup>(4)</sup>	150°C	150°C
	θ <sub>JA</sub> <sup>(4)</sup>	170°C/W	250°C/W
Operating Junction Temperature Range		–40°C to +85°C	
Storage Temperature Range		–65°C to +150°C	
Lead Temperature (Soldering, 10 seconds)		300°C	
ESD Rating		2 kV	

- (1) Absolute maximum ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device beyond its rated operating conditions.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) OUT may be shorted to GND for one second without damage. However, shorting OUT to V+ may damage the device and should be avoided. Also, for temperatures above 85°C, OUT must not be shorted to GND or V+, or device may be damaged.
- (4) The maximum allowable power dissipation is calculated by using  $P_{DMax} = (T_{JMax} - T_A) / \theta_{JA}$ , where  $T_{JMax}$  is the maximum junction temperature,  $T_A$  is the ambient temperature, and  $\theta_{JA}$  is the junction-to-ambient thermal resistance of the specified package.

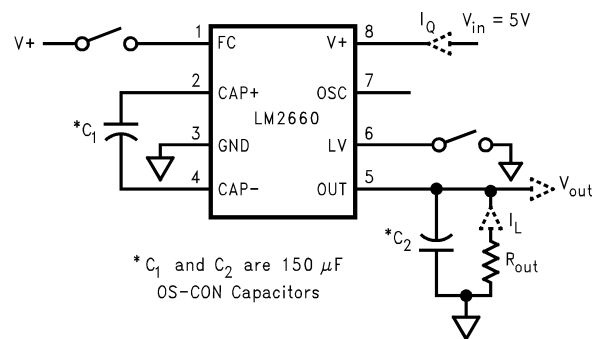
## Electrical Characteristics

Limits in standard typeface are for  $T_J = 25^\circ\text{C}$ , and limits in **boldface** type apply over the full operating temperature range. Unless otherwise specified:  $V_+ = 5\text{V}$ ,  $\text{FC} = \text{Open}$ ,  $C_1 = C_2 = 150\ \mu\text{F}$ . <sup>(1)</sup>

Symbol	Parameter	Condition		Min	Typ	Max	Units
$V_+$	Supply Voltage	$R_L = 1\text{k}$	Inverter, LV = Open	<b>3.5</b>		<b>5.5</b>	V
			Inverter, LV = GND	<b>1.5</b>		<b>5.5</b>	
			Doubler, LV = OUT	<b>2.5</b>		<b>5.5</b>	
$I_Q$	Supply Current	No Load	$\text{FC} = \text{Open}$		0.12	<b>0.5</b>	mA
		LV = Open	$\text{FC} = V_+$		1	<b>3</b>	
$I_L$	Output Current	$T_A \leq +85^\circ\text{C}$ , $\text{OUT} \leq -4\text{V}$		<b>100</b>			mA
		$T_A > +85^\circ\text{C}$ , $\text{OUT} \leq -3.8\text{V}$		<b>100</b>			
$R_{\text{OUT}}$	Output Resistance <sup>(2)</sup>	$I_L = 100\ \text{mA}$	$T_A \leq +85^\circ\text{C}$		6.5	<b>10</b>	$\Omega$
			$T_A > +85^\circ\text{C}$			<b>12</b>	
$f_{\text{OSC}}$	Oscillator Frequency	$\text{OSC} = \text{Open}$	$\text{FC} = \text{Open}$	<b>5</b>	10		kHz
			$\text{FC} = V_+$	<b>40</b>	80		
$f_{\text{SW}}$	Switching Frequency <sup>(3)</sup>	$\text{OSC} = \text{Open}$	$\text{FC} = \text{Open}$	<b>2.5</b>	5		kHz
			$\text{FC} = V_+$	<b>20</b>	40		
$I_{\text{OSC}}$	OSC Input Current	$\text{FC} = \text{Open}$			$\pm 2$		$\mu\text{A}$
		$\text{FC} = V_+$			$\pm 16$		
$P_{\text{EFF}}$	Power Efficiency	$R_L$ (1k) between $V_+$ and OUT		<b>96</b>	98		%
		$R_L$ (500) between GND and OUT		<b>92</b>	96		
		$I_L = 100\ \text{mA}$ to GND			88		
$V_{\text{OEFF}}$	Voltage Conversion Efficiency	No Load		<b>99</b>	99.96		%

- (1) In the test circuit, capacitors  $C_1$  and  $C_2$  are 0.2 $\Omega$  maximum ESR capacitors. Capacitors with higher ESR will increase output resistance, reduce output voltage and efficiency.  
(2) Specified output resistance includes internal switch resistance and capacitor ESR.  
(3) The output switches operate at one half of the oscillator frequency,  $f_{\text{OSC}} = 2f_{\text{SW}}$ .

## Test Circuits



**Figure 4. LM2660 Test Circuit**

## Typical Performance Characteristics

(Circuit of [Figure 4](#))

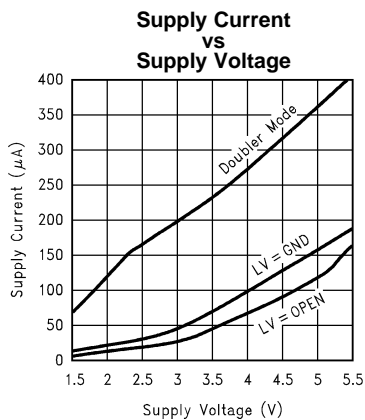


Figure 5.

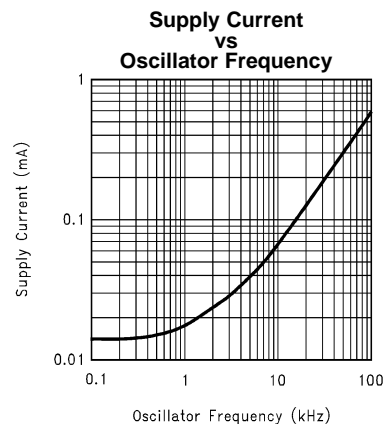


Figure 6.

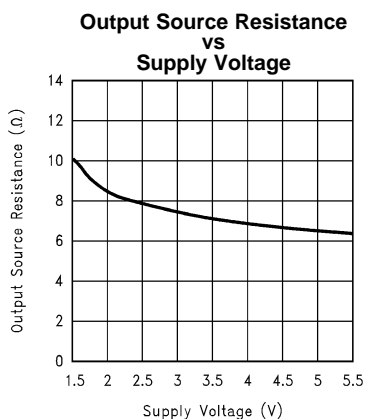


Figure 7.

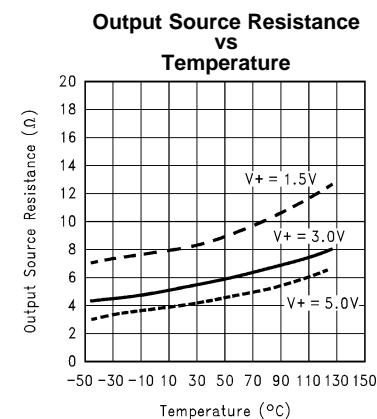


Figure 8.

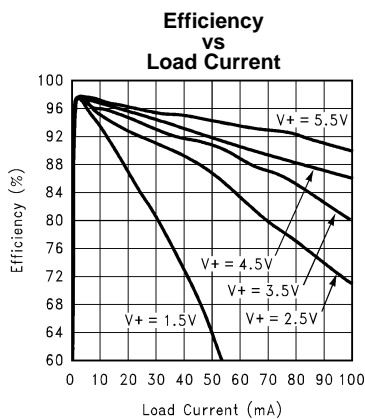


Figure 9.

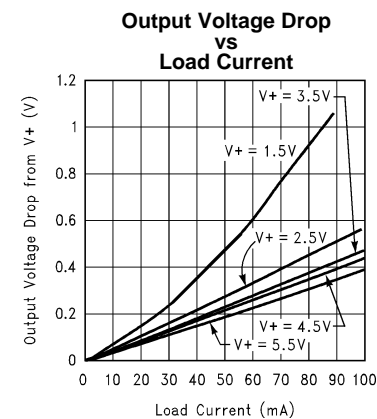


Figure 10.

## Typical Performance Characteristics (continued)

(Circuit of [Figure 4](#))

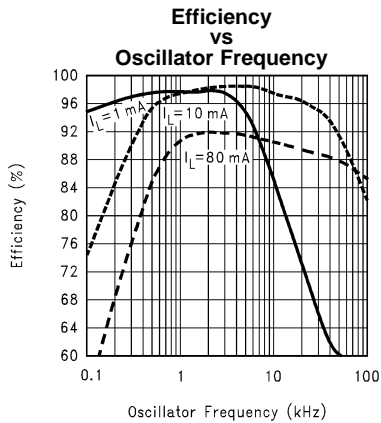


Figure 11.

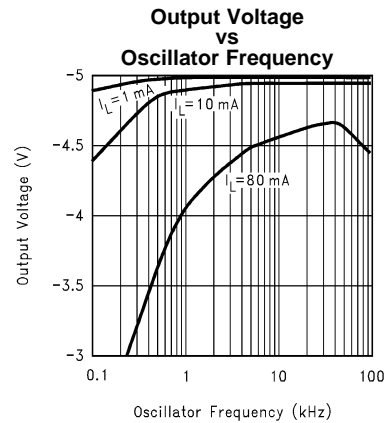


Figure 12.

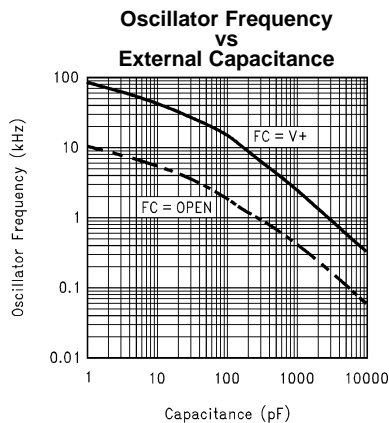


Figure 13.

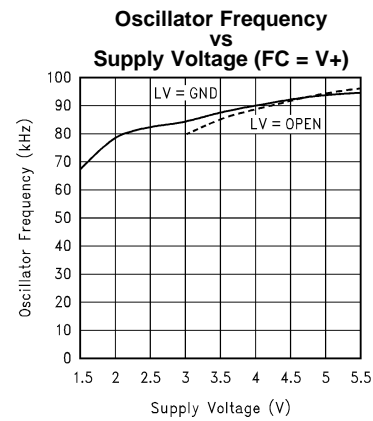


Figure 14.

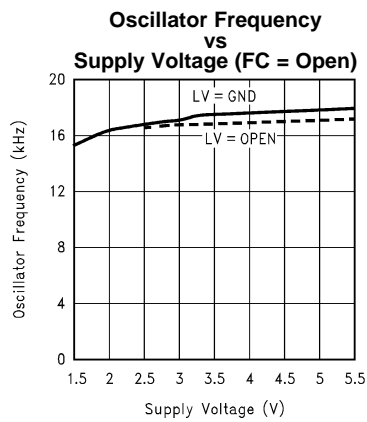


Figure 15.

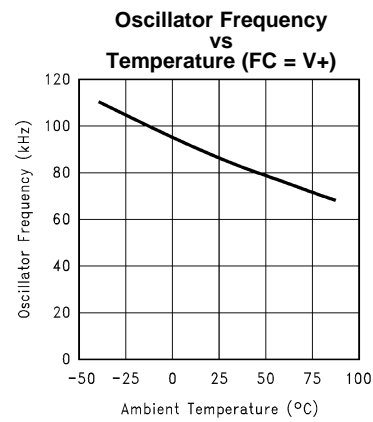
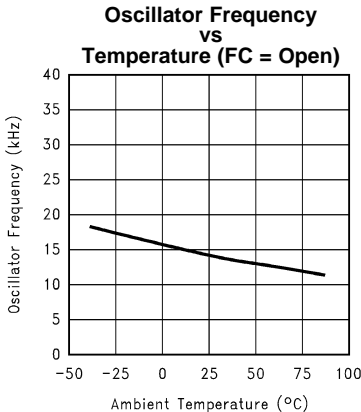


Figure 16.

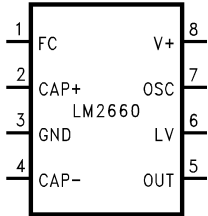
**Typical Performance Characteristics (continued)**

(Circuit of [Figure 4](#))



**Figure 17.**

**CONNECTION DIAGRAMS**



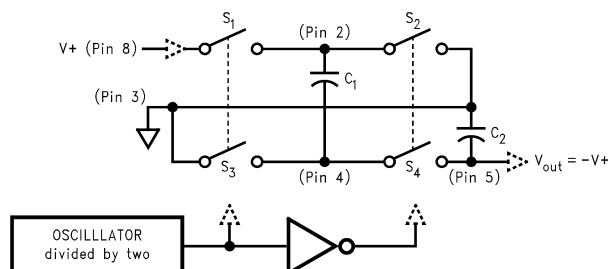
**Figure 18. Top View  
8-Lead SOIC (D) or VSSOP (DGK)**

**Pin Description**

Pin	Name	Function	
		Voltage Inverter	Voltage Doubler
1	FC	Frequency control for internal oscillator:	Same as inverter.
		FC = open, $f_{OSC} = 10 \text{ kHz (typ)}$ ;	
		FC = V+, $f_{OSC} = 80 \text{ kHz (typ)}$ ;	
		FC has no effect when OSC pin is driven externally.	
2	CAP+	Connect this pin to the positive terminal of charge-pump capacitor.	Same as inverter.
3	GND	Power supply ground input.	Power supply positive voltage input.
4	CAP-	Connect this pin to the negative terminal of charge-pump capacitor.	Same as inverter.
5	OUT	Negative voltage output.	Power supply ground input.
6	LV	Low-voltage operation input. Tie LV to GND when input voltage is less than 3.5V. Above 3.5V, LV can be connected to GND or left open. When driving OSC with an external clock, LV must be connected to GND.	LV must be tied to OUT.
7	OSC	Oscillator control input. OSC is connected to an internal 15 pF capacitor. An external capacitor can be connected to slow the oscillator. Also, an external clock can be used to drive OSC.	Same as inverter except that OSC cannot be driven by an external clock.
8	V+	Power supply positive voltage input.	Positive voltage output.

## Circuit Description

The LM2660 contains four large CMOS switches which are switched in a sequence to invert the input supply voltage. Energy transfer and storage are provided by external capacitors. Figure 19 illustrates the voltage conversion scheme. When  $S_1$  and  $S_3$  are closed,  $C_1$  charges to the supply voltage  $V+$ . During this time interval switches  $S_2$  and  $S_4$  are open. In the second time interval,  $S_1$  and  $S_3$  are open and  $S_2$  and  $S_4$  are closed,  $C_1$  is charging  $C_2$ . After a number of cycles, the voltage across  $C_2$  will be pumped to  $V+$ . Since the anode of  $C_2$  is connected to ground, the output at the cathode of  $C_2$  equals  $-(V+)$  assuming no load on  $C_2$ , no loss in the switches, and no ESR in the capacitors. In reality, the charge transfer efficiency depends on the switching frequency, the on-resistance of the switches, and the ESR of the capacitors.



**Figure 19. Voltage Inverting Principle**

## APPLICATION INFORMATION

### SIMPLE NEGATIVE VOLTAGE CONVERTER

The main application of LM2660 is to generate a negative supply voltage. The voltage inverter circuit uses only two external capacitors as shown in the [Basic Application Circuits](#). The range of the input supply voltage is 1.5V to 5.5V. For a supply voltage less than 3.5V, the LV pin must be connected to ground to bypass the internal regulator circuitry. This gives the best performance in low voltage applications. If the supply voltage is greater than 3.5V, LV may be connected to ground or left open. The choice of leaving LV open simplifies the direct substitution of the LM2660 for the LMC7660 Switched Capacitor Voltage Converter.

The output characteristics of this circuit can be approximated by an ideal voltage source in series with a resistor. The voltage source equals  $-(V_+)$ . The output resistance  $R_{out}$  is a function of the ON resistance of the internal MOS switches, the oscillator frequency, and the capacitance and ESR of  $C_1$  and  $C_2$ . A good approximation is:

$$R_{out} \cong 2R_{SW} + \frac{2}{f_{osc} \times C_1} + 4ESR_{C1} + ESR_{C2} \quad (1)$$

where  $R_{SW}$  is the sum of the ON resistance of the internal MOS switches shown in [Figure 19](#).

High value, low ESR capacitors will reduce the output resistance. Instead of increasing the capacitance, the oscillator frequency can be increased to reduce the  $2/(f_{osc} \times C_1)$  term. Once this term is trivial compared with  $R_{SW}$  and ESRs, further increasing in oscillator frequency and capacitance will become ineffective.

The peak-to-peak output voltage ripple is determined by the oscillator frequency, and the capacitance and ESR of the output capacitor  $C_2$ :

$$V_{ripple} = \frac{I_L}{f_{osc} \times C_2} + 2 \times I_L \times ESR_{C2} \quad (2)$$

Again, using a low ESR capacitor will result in lower ripple.

### POSITIVE VOLTAGE DOUBLER

The LM2660 can operate as a positive voltage doubler (as shown in the [Basic Application Circuits](#)). The doubling function is achieved by reversing some of the connections to the device. The input voltage is applied to the GND pin with an allowable voltage from 2.5V to 5.5V. The  $V_+$  pin is used as the output. The LV pin and OUT pin must be connected to ground. The OSC pin can not be driven by an external clock in this operation mode. The unloaded output voltage is twice of the input voltage and is not reduced by the diode  $D_1$ 's forward drop.

The Schottky diode  $D_1$  is only needed for start-up. The internal oscillator circuit uses the  $V_+$  pin and the LV pin (connected to ground in the voltage doubler circuit) as its power rails. Voltage across  $V_+$  and LV must be larger than 1.5V to insure the operation of the oscillator. During startup,  $D_1$  is used to charge up the voltage at  $V_+$  pin to start the oscillator; also, it protects the device from turning-on its own parasitic diode and potentially latching-up. Therefore, the Schottky diode  $D_1$  should have enough current carrying capability to charge the output capacitor at start-up, as well as a low forward voltage to prevent the internal parasitic diode from turning-on. A Schottky diode like 1N5817 can be used for most applications. If the input voltage ramp is less than 10V/ms, a smaller Schottky diode like MBR0520LT1 can be used to reduce the circuit size.

### SPLIT $V_+$ IN HALF

Another interesting application shown in the [Basic Application Circuits](#) is using the LM2660 as a precision voltage divider. Since the off-voltage across each switch equals  $V_{IN}/2$ , the input voltage can be raised to +11V.

### CHANGING OSCILLATOR FREQUENCY

The internal oscillator frequency can be selected using the Frequency Control (FC) pin. When FC is open, the oscillator frequency is 10 kHz; when FC is connected to  $V_+$ , the frequency increases to 80 kHz. A higher oscillator frequency allows smaller capacitors to be used for equivalent output resistance and ripple, but increases the typical supply current from 0.12 mA to 1 mA.

The oscillator frequency can be lowered by adding an external capacitor between OSC and GND. (See [Typical Performance Characteristics](#).) Also, in the inverter mode, an external clock that swings within 100 mV of  $V_+$  and GND can be used to drive OSC. Any CMOS logic gate is suitable for driving OSC. LV must be grounded when driving OSC. The maximum external clock frequency is limited to 150 kHz.



The switching frequency of the converter (also called the charge pump frequency) is half of the oscillator frequency.

#### NOTE

OSC cannot be driven by an external clock in the voltage-doubling mode.

**Table 1. LM2660 Oscillator Frequency Selection**

FC	OSC	Oscillator
Open	Open	10 kHz
V+	Open	80 kHz
Open or V+	External Capacitor	See <a href="#">Typical Performance Characteristics</a>
N/A	External Clock	External Clock
	(inverter mode only)	Frequency

## CAPACITOR SELECTION

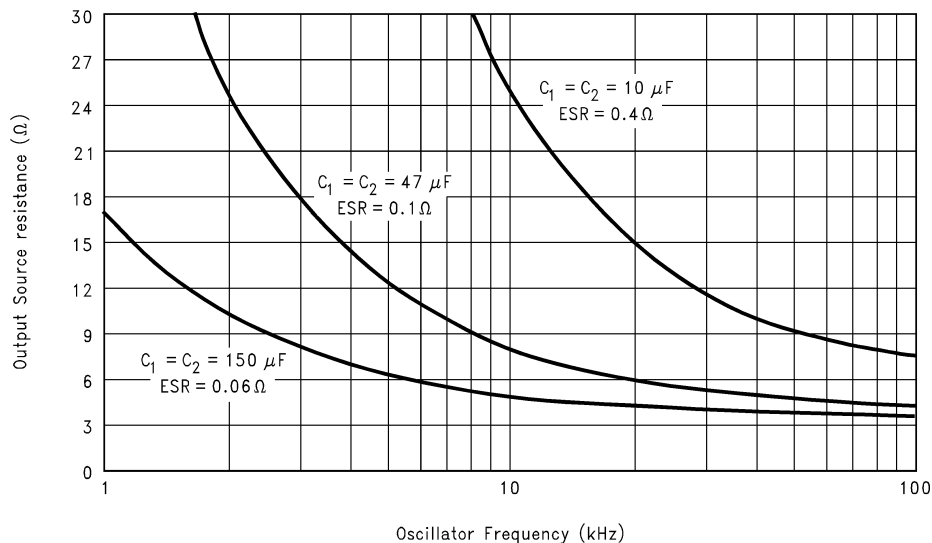
As discussed in the [SIMPLE NEGATIVE VOLTAGE CONVERTER](#) section, the output resistance and ripple voltage are dependent on the capacitance and ESR values of the external capacitors. The output voltage drop is the load current times the output resistance, and the power efficiency is

$$\eta = \frac{P_{out}}{P_{in}} = \frac{I_L^2 R_L}{I_L^2 R_L + I_L^2 R_{out} + I_Q(V+)} \quad (3)$$

Where  $I_Q(V+)$  is the quiescent power loss of the IC device, and  $I_L^2 R_{OUT}$  is the conversion loss associated with the switch on-resistance, the two external capacitors and their ESRs.

Since the switching current charging and discharging  $C_1$  is approximately twice as the output current, the effect of the ESR of the pumping capacitor  $C_1$  is multiplied by four in the output resistance. The output capacitor  $C_2$  is charging and discharging at a current approximately equal to the output current, therefore, its ESR only counts once in the output resistance. However, the ESR of  $C_2$  directly affects the output voltage ripple. Therefore, low ESR capacitors ([Table 2](#)) are recommended for both capacitors to maximize efficiency, reduce the output voltage drop and voltage ripple. For convenience,  $C_1$  and  $C_2$  are usually chosen to be the same.

The output resistance varies with the oscillator frequency and the capacitors. In [Figure 20](#), the output resistance vs. oscillator frequency curves are drawn for three different tantalum capacitors. At very low frequency range, capacitance plays the most important role in determining the output resistance. Once the frequency is increased to some point (such as 20 kHz for the 150  $\mu$ F capacitors), the output resistance is dominated by the ON resistance of the internal switches and the ESRs of the external capacitors. A low value, smaller size capacitor usually has a higher ESR compared with a bigger size capacitor of the same type. For lower ESR, use ceramic capacitors.



**Figure 20. Output Source Resistance vs Oscillator Frequency**

**Table 2. Low ESR Capacitor Manufacturers**

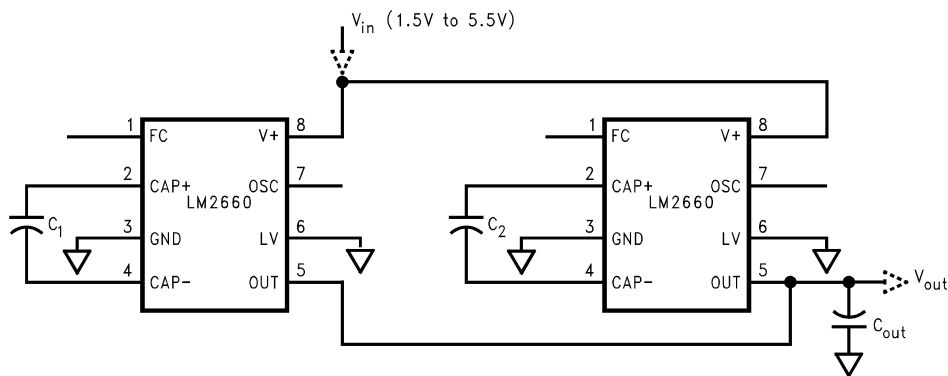
Manufacturer	Capacitor Type
Nichicon Corp.	PL, PF series, through-hole aluminum electrolytic
AVX Corp.	TPS series, surface-mount tantalum
Sprague	593D, 594D, 595D series, surface-mount tantalum
Sanyo	OS-CON series, through-hole aluminum electrolytic

## Other Applications

### PARALLELING DEVICES

Any number of LM2660s can be paralleled to reduce the output resistance. Each device must have its own pumping capacitor  $C_1$ , while only one output capacitor  $C_{out}$  is needed as shown in [Figure 21](#). The composite output resistance is:

$$R_{out} = \frac{R_{out \text{ of each LM2660}}}{\text{Number of Devices}} \quad (4)$$



**Figure 21. Lowering Output Resistance by Paralleling Devices**

## CASCADING DEVICES

Cascading the LM2660s is an easy way to produce a greater negative voltage (as shown in Figure 22). If  $n$  is the integer representing the number of devices cascaded, the unloaded output voltage  $V_{out}$  is  $(-nV_{in})$ . The effective output resistance is equal to the weighted sum of each individual device:

$$R_{out} = nR_{out\_1} + \frac{n}{2}R_{out\_2} + \dots + R_{out\_n} \quad (5)$$

A three-stage cascade circuit shown in Figure 23 generates  $-3V_{in}$  from  $V_{in}$ .

Cascading is also possible when devices are operating in doubling mode. In Figure 24, two devices are cascaded to generate  $3V_{in}$ .

An example of using the circuit in Figure 23 or Figure 24 is generating +15V or -15V from a +5V input.

Note that, the number of  $n$  is practically limited since the increasing of  $n$  significantly reduces the efficiency and increases the output resistance and output voltage ripple.

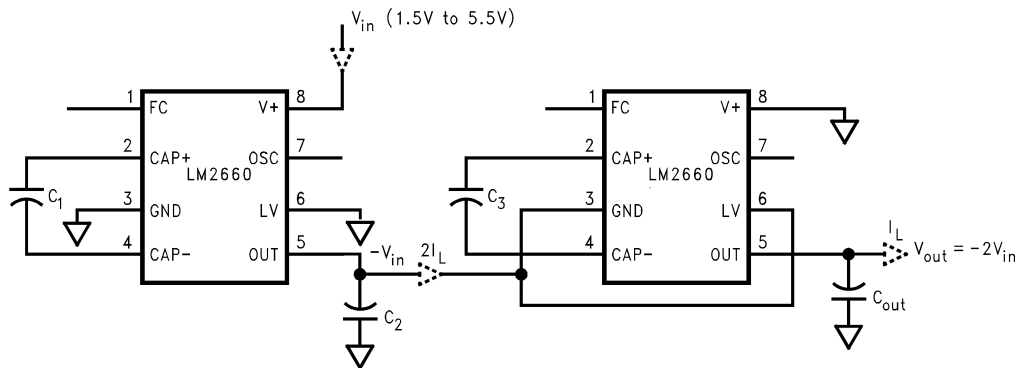


Figure 22. Increasing Output Voltage by Cascading Devices

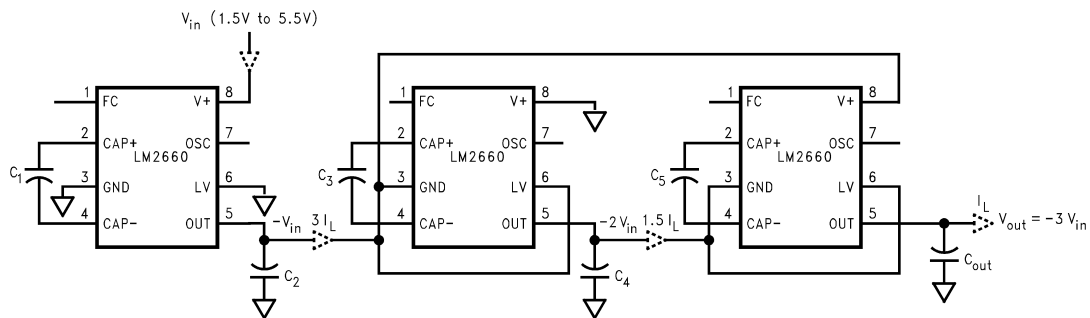


Figure 23. Generating  $-3V_{in}$  from  $+V_{in}$

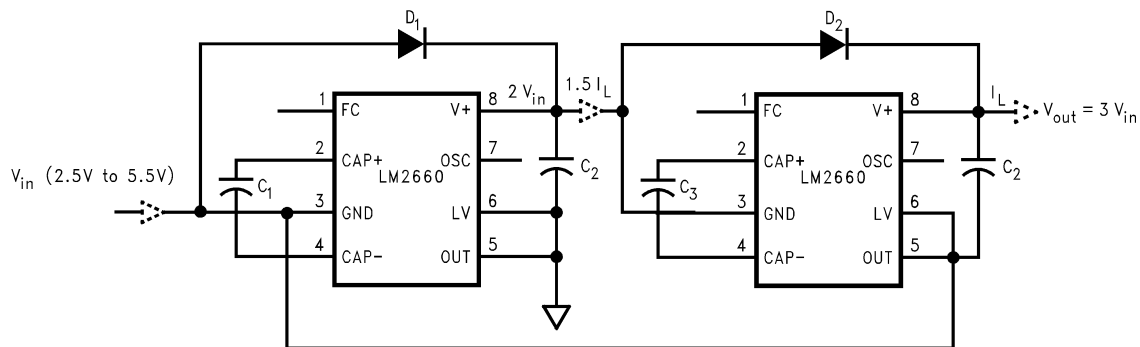


Figure 24. Generating  $+3V_{in}$  from  $+V_{in}$

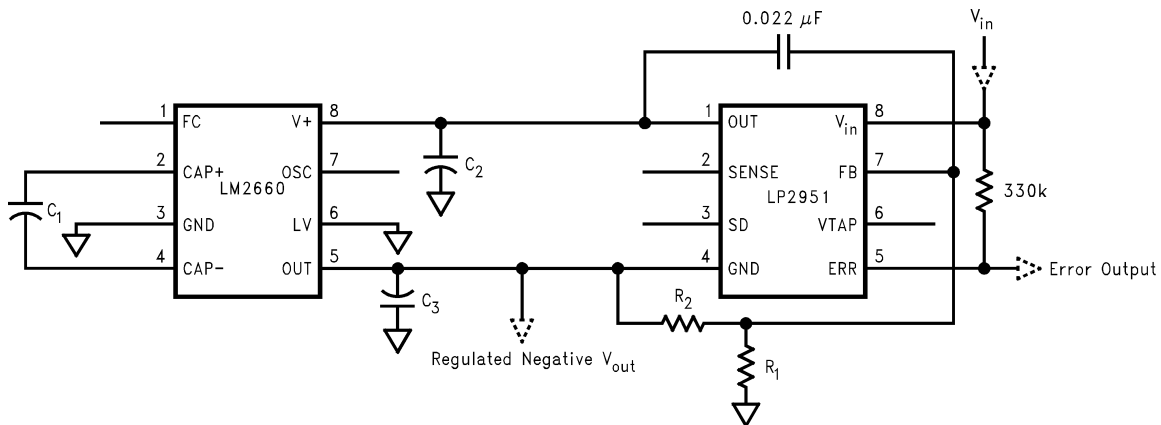
## REGULATING $V_{out}$

It is possible to regulate the output of the LM2660 by use of a low dropout regulator (such as LP2951). The whole converter is depicted in [Figure 25](#). This converter can give a regulated output from  $-1.5V$  to  $-5.5V$  by choosing the proper resistor ratio:

$$V_{out} = V_{ref} \left( 1 + \frac{R_1}{R_2} \right) \quad (6)$$

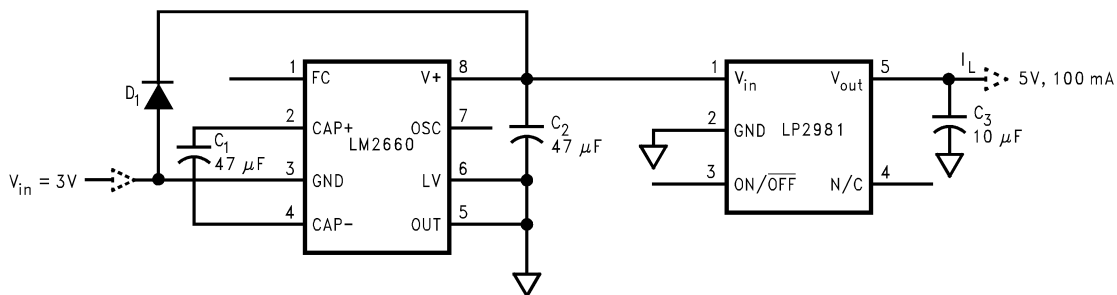
where,  $V_{ref} = 1.235V$

The error flag on pin 5 of the LP2951 goes low when the regulated output at pin 4 drops by about 5%. The LP2951 can be shutdown by taking pin 3 high.



**Figure 25. Combining LM2660 with LP2951 to Make a Negative Adjustable Regulator**

Also, as shown in [Figure 26](#) by operating LM2660 in voltage doubling mode and adding a linear regulator (such as LP2981) at the output, we can get  $+5V$  output from an input as low as  $+3V$ .



**Figure 26. Generating +5V from +3V Input Voltage**

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LM2660M	ACTIVE	SOIC	D	8	95	TBD	CU SNPB	Level-1-235C-UNLIM	-40 to 85	LM26 60M	<a href="#">Samples</a>
LM2660M/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	LM26 60M	<a href="#">Samples</a>
LM2660MM	ACTIVE	VSSOP	DGK	8	1000	TBD	CU SNPB	Level-1-260C-UNLIM	-40 to 85	S01A	<a href="#">Samples</a>
LM2660MM/NOPB	ACTIVE	VSSOP	DGK	8	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	S01A	<a href="#">Samples</a>
LM2660MX	ACTIVE	SOIC	D	8	2500	TBD	CU SNPB	Level-1-235C-UNLIM	-40 to 85	LM26 60M	<a href="#">Samples</a>
LM2660MX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	LM26 60M	<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Only one of markings shown within the brackets will appear on the physical device.

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**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM2660MM	VSSOP	DGK	8	1000	178.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM2660MM/NOPB	VSSOP	DGK	8	1000	178.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM2660MX	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM2660MX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM2660MM	VSSOP	DGK	8	1000	203.0	190.0	41.0
LM2660MM/NOPB	VSSOP	DGK	8	1000	203.0	190.0	41.0
LM2660MX	SOIC	D	8	2500	349.0	337.0	45.0
LM2660MX/NOPB	SOIC	D	8	2500	349.0	337.0	45.0



DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



## NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
- E. Falls within JEDEC MO-187 variation AA, except interlead flash.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



## NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- $\triangle C$  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS-012 variation AA.

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